Project Overview

John Hamilton,
Co-I Science Team, UH Hilo PI
Biologic Analog Science Associated with Lava Terrains – Conops Development for Future Human Exploration of Mars

Planetary Science and Technology from Analog Research (PSTAR) program addresses the need for integrated interdisciplinary field experiments as an integral part of preparation for planned human and robotic missions.

- Furthermore, the program solicits proposals for investigations focused on exploring the Earth’s extreme environments in order to develop a sound technical and scientific basis to conduct astrobiological research on other solar system bodies.
- The focus of this program element is on providing high-fidelity scientific investigations, scientific input, and science operations constraints in the context of planetary field campaigns.

PSTAR solicitation is a consolidation of two previous calls: Astrobiology Science and Technology for Exploring Planets (ASTEP) and Moon Mars Analogue and Mission Activities (MMAMA).

https://spacescience.arc.nasa.gov/basalt/
https://twitter.com/basalt_research?lang=en
Project Goals

Science:
The BASALT science program is focused on understanding habitability conditions of early and present-day Mars in two relevant Mars-analog locations (the Southwest Rift Zone (SWRZ) and the East Rift Zone (ERZ) flows on the Big Island of Hawai‘i and the eastern Snake River Plain (ESRP) in Idaho) to characterize and compare the physical and geochemical conditions of life in these environments and to learn how to seek, identify, and characterize life and life-related chemistry in basaltic environments representing these two epochs of martian history.

Science Operations:
The BASALT team will conduct real (non-simulated) biological and geological science at two high-fidelity Mars analogs, all within simulated Mars mission conditions (including communication latencies and bandwidth constraints) that are based on current architectural assumptions for Mars exploration missions. We will identify which human-robotic ConOps and supporting capabilities enable science return and discovery.

Technology:
BASALT will incorporate and evaluate technologies in to our field operations that are directly relevant to conducting the scientific investigations regarding life and life-related chemistry in Mars-analogous terrestrial environments. BASALT technologies include the use of mobile science platforms, extravehicular informatics, display technologies, communication & navigation packages, remote sensing, advanced science mission planning tools, and scientifically-relevant instrument packages to achieve the project goals.
What?

- BASALT is an international team of scientists, engineers, mission operators, and astronauts who are dedicated to enabling the human-robotic exploration of Mars!
- 4 NASA Centers: Ames Research Center, Goddard Space Flight Center, Kennedy Space Center, Johnson Space Center
- 4 Universities: McMaster University (Canada), Univ. of Edinburgh (UK), Idaho State Univ., Univ. of Hawai`i - Hilo
How?

• The drive to discover and explore our Solar System will benefit from and ultimately demand the infusion of science into the operational framework and execution cadence of the mission. From an early stage in the architecture development process we are designing the “How?” in such a way that supports both the well-being of astronauts and their ability to conduct meaningful, productive, and efficient scientific exploration.

• By examining the minerology of basalts, one can determine the moisture conditions during eruptions and look for changes due to both water and microbial life (bio-alterations).
Milestones

• June 2015 – Face to Face Kickoff Meeting – Ames Research Center

• Oct 2015 – Hawai’i Recon for operations sites, HVNP

• June 2016 – The first round of BASALT field tests, at Craters of the Moon National Monument and Preserve, in Idaho. The site was an analog to present-day Mars, where most evidence for the type of volcanism studied by the project is from a more active past thousands of years ago.

• November 2016 – BASALT's second field test, on the lava flows of Mauna Ulu, on the Big Island of Hawaii. This volcanically active location was an analog environment for early Mars.

• July 2017 – Operations Readiness Test – Ames

• November 2017 – The third and final season of testing for BASALT was held at Kilauea Iki and Kilauea Caldera Region, Hawaii Volcanoes National Park – also an analog environment for early Mars.

• December 2018 – AGU Washington DC

• March 2019 – The journal Astrobiology published a special issue devoted to the science, technology and engineering of future human space exploration studied by the BASALT research program: “The BASALT Program: Analog research in support of human scientific exploration of Mars.”

• December 2019 – AGU San Francisco
Face to Face Meeting @ ARC 2-4 June 2015

K-Rex rover on Ames Rock Yard
Viewed by Astronaut Jeff Hoffman

Rock Yards are laboratory (artificial) versions of analog sites.
CotM

Landsat Image
Craters of the Moon National Monument
Radio Comm Link – 22 Miles
Mars to Earth
Darlene Lim, BASALT Lead Principal Investigator. Astrogeobiologist
Science Backroom Team on call!
Humming along on Mission Day 1
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Traverse Planning & Evaluation (live GPS tracking)
Tools of the Trade (a la Star Trek)

TerraSpec Halo
Portable Vis-NIR Spectrometer

Range: 350-2500 nm
Resolution: 3 nm @ 700 nm
9.8 nm @ 1400 nm
8.1 nm @ 2100 nm

Thermo X-Ray Fluorescence Spectrometer (XRF)

~ $30,000
Chris and Shannon w/ UHH support
Comms Recon at Mauna Ulu

NASA KSC and UHH fix line-of-sight radio to HVO then relay to Kilauea Military Camp
Mauna Ulu
Jaggar Museum
HVO
Kilauea Military Camp

1.4 miles

~8 Miles

Mauna Ulu Summit
Kilauea Military Camp aka “Earth”

• Science Backroom
The Software Support behind the Science Team
Leader Board
OWLT and BW

- Communication latency will occur between Mars and Earth, ranging from 4 to 22 min one-way light time (OWLT) (8–44 min round trip). The question remains as to when and how Earth-based support could assist during EVAs.

Radio vs Laser: Bandwidth afforded by communications architecture will impact the ability to share data products and other communications between space and ground during EVA.
Mission Architecture
Simulation
Astronauts
Mars Surface
EVA

Mauna Ulu
and Kilauea

Realtime

Mars Base
support
Astronauts

KMC
(Quarantined)

Earth Science
Backroom
support

Time Delay
(5 and 20min)

Kilauea
Military
Camp
Another Day back on Earth
Mars Base
Communications Architecture
EV backpacks
BASALT FIELD SUPPORT TEAM

WE SIT, WE STAND, WE HAND
Group Photo
Time
Not every day is sunny
Science team members discussing tactical sampling priorities for today's EVA.
Learning Experimental Instrument
Samples (LEIS)
Examples & Frozen Samples
Last day of Operations – Science Team
Altered BASALT on Mauna Ulu
Tartigrade outcrop.
Astronaut in Training - summit of Mauna Ulu
Stan Love – in the field and The Martian commentator
BASALT is developing the geology and biology sampling protocols for future Mars astronauts as well as concepts of operations involving traverse planning and execution under time-delay and high/low communication bandwidth conditions.
Astronaut Jeff Hoffman and crew
Kilauea Military Camp
Science Backroom, Earth
Hawai`i 2017
Science Deployment areas
Keanakekoi and Kilauea Iki
ROI – Keanakekoi DEM
Keanakekoi - Slopes
Kilauea Iki - ROI
Kilauea Iki - DEM
Kilauea Iki - Slopes
Kilauea Iki – Minerology 1
Kilauea Iki – Minerology 2
Kilauea Iki - Thermal
1. BASALT: The Future of Mars, on Earth Today - Stanley G. Love
2. The BASALT Research Program: Designing and Developing Mission Elements in Support of Human Scientific Exploration of Mars
3. Basaltic Terrains in Idaho and Hawai‘i as Planetary Analogs for Mars Geology and Astrobiology
4. A Low-Diversity Microbiota Inhabits Extreme Terrestrial Basaltic Terrains and Their Fumaroles: Implications for the Exploration of Mars
6. Assessing the Acceptability of Science Operations Concepts and the Level of Mission Enhancement of Capabilities for Human Mars Exploration Extravehicular Activity
7. Strategic Planning Insights for Future Science-Driven Extravehicular Activity on Mars
8. Tactical Scientific Decision-Making during Crewed Astrobiology Mars Missions
10. Requirements for Portable Instrument Suites during Human Scientific Exploration of Mars
11. Opportunities and Challenges of Promoting Scientific Dialog throughout Execution of Future Science-Driven Extravehicular Activity
12. Future Needs for Science-Driven Geospatial and Temporal Extravehicular Activity Planning and Execution
14. A Flexible Telecommunication Architecture for Human Planetary Exploration Based on the BASALT Science-Driven Mars Analog